A TAXONOMIC REVIEW OF THE GENUS *MIXOPHYES*, (ANURA, LEPTODACTYLIDAE)

I. R. Straughan
Department of Zoology, University College of Townsville, Townsville, Queensland

(Plates i–ii)

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Synopsis

Two species of *Mixophyes* Günther are described and the two subspecies already defined are elevated to species.

Introduction

Moore (1961, p. 165) suggested that *Mixophyes* from northern New South Wales might fall into two species—one from mountain streams and the other from large coastal rivers. Analysis of additional material of *Mixophyes* collected by the author from northern New South Wales and southern Queensland shows that three easily distinguishable morphological types, each with a distinct call, are recognisable. Also the geographically isolated *Mixophyes* from northern Queensland is distinct in morphology and call from any of the southern forms. These four species are described in this paper.

Material and Methods

All the material listed by locality (tabulated north to south) was collected by the author from breeding congresses during summers from 1960 to 1967 inclusive. This material is lodged with the Queensland Museum, Brisbane. All material in the Australian Museum (Sydney) collections was examined. Specimens examined by Moore (*op. cit.*) in the American Museum of Natural History were not seen. Synonymies include the original reference, reference to Parker (1940) who gives complete synonymies to that date, and all subsequent references. The descriptions follow the pattern suggested by Moore (*op. cit.*, p. 155). Length of inner metatarsal tubercle was measured along its long axis, and length of first toe from its tip to its junction with inner metatarsal tubercle. A key to all the known species of *Mixophyes* is provided.

Mixophyes fasciolatus Günther

(Pl. i, Fig. 1)

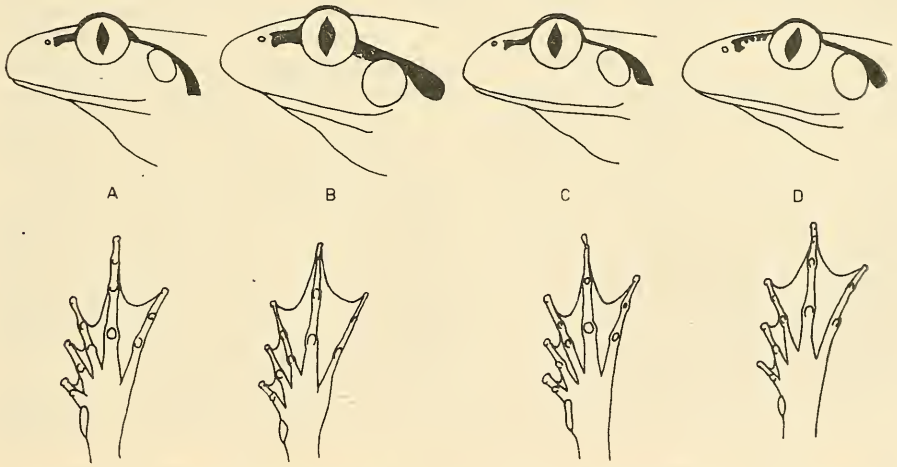
Mixophyes fasciolatus Günther, 1864, p. 46, pl. 7, fig. 1. *Mixophyes fasciolatus* Günther, Slevin, 1955, p. 359 [part.]; Moore, 1961, p. 162, fig. 1 [part.]. *Mixophyes fasciolatus fasciolatus* Günther, Parker, 1940, with complete synonymy (delete Fletcher, 1892, p. 18).

Type locality: Clarence River, N.S.W. Topotypic material 3 ♂♂, 1 ♀, collected two miles east of Grafton, Clarence River, 17-III-1963.

Diagnosis: Species of *Mixophyes* are distinguishable from all other Australian frogs by pupil vertical when constricted; vomerine teeth in front of choanae; round tongue, only 1/4 to 1/5 free behind; distinct tympanum; limbs with dark cross bars; and feet with well developed web.

Mixophyes fasciolatus is distinguished from its congeners by web to distal sub-articular tubercle on outer margin of third toe; three joints of fourth toe free of web; inner metatarsal tubercle as long as first toe; dark cross bars on limbs narrower than intervening light; lateral zone of dark spots dividing dark dorsal and white ventral surfaces; outer metacarpal tubercle well developed; tympanum oval, long axis tilted towards eye.

Description: Large (60–80 mm., snout-vent length) with long barred legs. Dorsal surface smooth to finely granular; tan to pale grey marked with darker blotches: characteristically a dark mid-dorsal band present, commencing as interorbital Y or T continuing posteriorly with irregular margins. Band may be broken into less regular blotches, in extreme cases leaving only interorbital bar and oblique elongate patches scattered over remainder. Junction of dark dorsal and pale ventral surfaces marked by series of irregular dark lateral spots between arm and groin. Distinct black head stripe from behind nostril, through eye, above tympanum, curving round its upper margin, ending at level of lower margin and separated from it by width of stripe (Fig. 1c). Triangular patch in front of nostril with base along upper lip



Text-fig. 1. General head profiles and hind feet of *Mixophyes*, spp., showing head stripes, shape of snout, position of tympanum, extent of webbing, and size of inner metatarsal shovel. a.—*M. balbus*, b.—*M. iteratus*, c.—*M. fasciolatus*, d.—*M. schevilli*.

and apex at nostril. Dorsal surfaces of limbs with dark cross bands not as wide as intervening pale. Bands widening on margins of limbs to form dark and light saw tooth pattern, breaking up irregularly on posterior surface of thigh producing rough marble pattern. Ventral surface, including limbs, white, smooth except for area around vent. Base of triangular expansion of dark limb bars visible from below. Chin and throat dusted with dark. Tympanum distinct, oval, long axis tilted towards eye from vertical (Fig 1c). Fingers unwebbed, in order of length $3 > 4 = 1 > 2$. Elongate well-developed inner, and smaller well-developed oval, outer metacarpal tubercle. Webbing between toes strong. First toe free of web to proximal sub-articular tubercle, as is second on inner edge. On outer edge of second, fringe of web to dilated tip. Web only to proximal sub-articular tubercle of third on inner edge and

to distal on outer edge. Three joints of fourth free. Fifth webbed to tip, but web reaching only to level of distal sub-articular tubercle at lowest point between fourth and fifth (Fig. 1c). No outer metatarsal tubercle but well-developed, shovelshaped, inner metatarsal tubercle as long as first toe. Sub-articular tubercles oval moderately developed (Fig. 1c). Vomerine teeth platelike, directed towards each other from anterior margin of choanae to midline between choanae, nearly touching.

Material examined: *Queensland*: Mount Cooroy 2 ♂♂; Jimna Range 5 ♂♂; Nanango 3 ♂♂; Kumbia 2 ♂♂; Yarraman State Forest 3 ♂♂; Yarraman 7 ♂♂; Bunya Mountains 17 ♂♂, 3 ♀♀; Blackbutt 4 ♂♂; Maleny 12 ♂♂, 7 ♀♀; Upper Brisbane River 6 ♂♂; Chevellum 4 ♂♂; Woodford 3 ♂♂; D'Aguilar 2 ♂♂; Mount Mee 14 ♂♂, 11 ♀♀; Ravensbourne National Park 1 ♂; Mount Glorious-Mount Nebo 107 ♂♂, 42 ♀♀; Samford 5 ♂♂; Withcott 4 ♂♂; Lake Manchester 7 ♂♂, 2 ♀♀; Gold Creek Road 4 ♂♂; Ma Ma Creek 1 ♀; Mount Tambourine 18 ♂♂, 3 ♀♀; Cunningham's Gap 21 ♂♂, 4 ♀♀; Nerang River 3 ♂♂; Spicer's Gap 1 ♂; Beechmont 1 ♀; Springbrook 11 ♂♂; Binna Burra 4 ♂♂; Christmas Creek 14 ♂♂; Coomera Gorge 1 ♂; Currumbin Creek 7 ♂♂, 1 ♀; Queen Mary's Falls National Park 14 ♂♂, 3 ♀♀; Mount Lindsay 2 ♂♂. *New South Wales*: Chillingham 5 ♂♂, 1 ♀; North Arm Tweed River near Murwillumbah 31 ♂♂, 12 ♀♀; Island in Tweed River 2 ♂♂; Woodenbong 3 ♂♂; Tweed River, Mount Warning 6 ♂♂; Richmond River (4 miles north of Kyogle) 1 ♂; Ulong 2 ♂♂; Upper Clarence River 7 ♂♂; Richmond River (south of Kyogle) 4 ♂♂; Grafton 3 ♂♂, 1 ♀; Point Lookout, New England National Park 51 ♂♂. *Australian Museum*: 6791 ♂, Clarence River (N.S.W.); 6794 ♂, Pine Mountain (Qd.); R.4247 ♂, Warrell Creek, Nambucca (N.S.W.; R.5090 ♂, Richmond River (N.S.W.); R.5872 ♂, R.5873 ♂, R.5876 ♂, R.5877 ♂, Nambucca River (N.S.W.); R.6265 ♂, R.6287 ♂, R.6289 ♂, R.6291 ♂, Gurravembi, Nambucca River (N.S.W.); R.6499 Juvenile, Avoca, via Gosford (N.S.W.); R.7463 ♂, Dunoon, Richmond River (N.S.W.); R.8472, Juvenile, Avoca, via Gosford (N.S.W.); R.8937 ♂, R.8939 ♂, Mount Tambourine (Qd); R.10456 ♂, Dorrigo Scrub (N.S.W.); R.10506 ♂, Wyong (N.S.W.); R.12081, Juvenile, Palmdale, Wyong (N.S.W.); R.12645 ♂, R.12646 ♂, R.12647 ♂, R.12649 ♂, R.12650 ♂, R.12651 ♂, R.12653 ♂, R.12654 ♂, R.12655 ♂, R.12656 ♂, Lowana, Dorrigo (N.S.W.); R.13543 ♂, Old Koreelah (N.S.W.); R. 15127 ♂, R.16945 ♂, R.17698 ♂, Bunya Mountains (Qd.); R.16922, Juvenile, Mount Glorious (Qd.); R.20498, Juvenile, Guineacor Caves, Wombeyan Caves (N.S.W.).

Distribution: Along and east of the Great Dividing Range from Bundaberg (Qd.) in the north to Gosford and Wombeyan Caves (N.S.W.) in the south.

Mixophyes iteratus, sp. nov.

(Pl. 1, Fig. 2)

Mixophyes fasciolatus Günther; Fletcher, 1892, p. 18; Slevin, 1955, p. 359 [part.]; Moore, 1961, p. 163 [part.].

Type locality: Tweed River, Mount Warning, N.S.W.

Holotype: Australian Museum Reg. No. R.25929, ♂, collected 23-XII-1963.

Paratypes: 1 ♀ Australian Museum; 1 ♂, 1 ♀ Queensland Museum, collected same time and place as holotype.

Diagnosis: Distinguishable from frogs of other genera by the six features listed for *M. fasciolatus,* and from its congeners by web to tip of first, third, and fifth toes; two joints of fourth toe free of web; inner metatarsal tubercle strongly developed but relatively short—half as long as first toe; dark cross bars on limbs as wide as intervening light; tympanum almost round, long axis vertical; skin very granular on back and legs; and pointed snout.

Description: Extremely large for Australian frogs (80–115 mm. snout-vent), strongly developed hind legs and webbed feet, resembling *Rana*.

Holotypes: Back finely granular, dark olive to black almost obscuring typical *Mixophyes* dorsal patterning. Dark head stripe broad, almost same width throughout except above tympanum, where it narrows to thin line on edge of supra-tympanic fold (Fig. 1b). Broad lateral band of spots tending to irregular mottling between arm and groin. Dark cross bars on dorsal surface of limbs as wide as intervening olive, not expanded on margins. On posterior surface of thighs, cross bars coalese forming uniform dark background with few distinct yellow spots of diameter approximately equal to width of cross bars. Ventral surface smooth, white on belly limbs. Fine darker dusting on chin. Tympanum distinct, almost round, long axis vertical. Sharp supra-tympanic fold (Fig. 1b). Fingers without web, arranged in order of length: $3 > 4 > 1 > 2$. Inner metacarpal tubercle, oval, well developed. Outer almost flat on palm. Nuptial pad on first finger only thin strip along inner edge. Toes fully webbed, reaching tip of first, second, and third toes on outer margins and tip of fifth. On inner edges of second and third to proximal and distal sub-articular tubercles, respectively. Only two joints of fourth toe free of web, narrow fringe to tip on outer margin (Fig. 1b). Inner metatarsal tubercle without well-developed shovel edge, length equal to half of first toe (measured from tip to its junction with tubercle). Sub-articular tubercles elongate, flattened. No outer metatarsal tubercle. Vomerine teeth in slightly oblique transverse series, almost meeting in midline, almost entirely in front of choanae.

Snout-vent length 80·5 mm.

Variation: Three paratypes and other specimens examined vary little from holotype. Females larger than males (> 100 mm.), skin with texture of coarse sandpaper. Dorsal colour from pale olive to dark bottle green.

Material examined: *Queensland*: Kumbia 1 ♂; Bunya Mountains 3 ♂♂, 1 ♀; Cunningham's Gap 5 ♂♂; Queen Mary's Falls National Park 2 ♂♂, 2 ♀♀; Mount Lindsay 2 ♂♂, 1 ♀. *New South Wales*: Upper Richmond River (6 miles north of Kyogle), 7 ♂♂, 1 ♀; Tweed River, Mount Warning, 4 ♂♂, 2 ♀. *Australian Museum*: R.7493 ♀, R.7494 ♀, Dunoon, Richmond River (N.S.W.); R.7550 ♂, Dorrigo (N.S.W.); R.12308 ♀, Mullumbimby (N.S.W.); R.12642 ♂, R.12643 ♀, R.12644 ♀, Lowana, Dorrigo (N.S.W.); R.16762 ♀, Coolmangar, via Lismore (N.S.W.); R.16946 ♂, Mullumbimby (N.S.W.); R.19038 ♀, R.19039 ♀, R.19040 ♀, R.19041 ♂, R.19042 ♂, Wallaby Creek, Urbenville (N.S.W.); R.25877 ♀, Ourimah (N.S.W.).

Distribution: Bunya Mountains and along the Queensland-New South Wales border east of Stanthorpe, south to the Dorrigo Plateau, N.S.W.

Mixophyes balbus, sp. nov.

(Pl. II, Fig. 1)

Mixophyes fasciolatus Günther, Moore, 1961, p. 162.

Type locality: Point Lookout, New England National Park, N.S.W., between 4,250 and 4,750 feet altitude.

Holotype: ♂ Australian Museum Reg. No. R.25922 collected 15-X-1965.

Paratypes: 10 ♂♂, 3 ♀♀ collected same time and place as holotype, by I. R. Straughan and A. R. Main (Australian Museum and Queensland Museum).

Diagnosis: Distinguished from other Australian frogs by six features listed for *M. fasciolatus*; and from other *Mixophyes* species by web extending only to distal sub-articular tubercle of third toe on outer margin, three joints

of fourth toe free of web; inner metatarsal tubercle well-developed shovel, equal in length to first toe; cross bars on dorsal surface of limbs narrow, not distinct over whole surface, without distinct triangular bands on margins of limbs; dorsal surface diffuses laterally to merge with white ventral, without sharp change marked by narrow zone of dark dots; males with well-developed nuptial pads on metacarpal, first and second fingers; and oval tympanum, long axis directed obliquely towards eye.

Description: Large frogs (60–80 mm. snout-vent length) with strong limbs poorly marked by dark cross bars.

Holotype: Dorsal surface yellowish grey (grey in alcohol) diffusing gradually into white ventral. Lateral surface not marked with dark spots. Dark markings of typical *Mixophyes* pattern—interorbital T extending posteriorly as broad mid-dorsal stripe of irregular outline; few scattered irregular dark patches on remainder of back. Dark head stripe, bold between nostril and eye, thin line above tympanum (Fig. 1a). Triangular patch in front of nostril, not as dark as head stripe, with well marked edge. Bars on dorsal surface of limbs narrower than intervening light, not distinct over whole surface, broadening terminally, but not forming distinct triangles on margins of limbs. Extremities of dark limb bars not visible from below. Posterior surface of thigh diffusely speckled with dark. Ventral surface of body and limbs white, hands and feet darker, chin dusted with darker. Tympanum distinct, dorsal margin obscured in head stripe and supratympanic fold, oval, long axis directed towards eye (Fig. 1a). Fingers without web, stouter than in other species of *Mixophyes*, in order of length $3 > 4 > 1 = 2$. Inner metacarpal tubercle elongate, strongly developed; outer oval and equally developed. Dark horny nuptial pad covering dorsal surface of first finger except for distal phalanx; separate round pad on inner surface of inner metacarpus and tubercle; and thin strip dorsally on inner edge of second finger. Toes webbed to: sub-articular tubercle of first, proximal sub-articular tubercle of second and third on inner margins, tip and distal sub-articular tubercle on outer margins of second and third respectively, and tip of fifth. Three joints of fourth toe free of web, narrow fringe along outer edge to tip (Fig. 1a). Inner metatarsal tubercle strongly shovel-shaped, basal length approximately equal to length of first toe (measured from tip of toe to junction with tubercle). No outer metatarsal tubercle. Sub-articular tubercles variably developed. Vomerine teeth typical of *Mixophyes*—transverse plates in front of choanae almost joining in midline, directed slightly backwards towards midline.

Snout-vent length = 75·0 mm.

Variation: Webbing consistent on both sexes. Females without nuptial pads, more slender fingers. First, second, and fourth fingers almost equal in length, not always in same order as type (any order possible). Dorsal pattern with similar variation to other species of *Mixophyes*—less regular dark markings. Spots of dark in groin and behind arm in some females, not marking a zone of sharp transition from dark dorsal to white ventral colouring.

Material examined: *New South Wales*: Point Lookout, altitude 4,500 to 4,750 feet, 14 ♂♂, 5 ♀♀, 16-X-1965; Point Lookout, ca. 4,250 feet, 27 ♂♂ (21 sympatric with *M. fasciolatus*), 19-II-1966. *Australian Museum*: R.7479 ♂, Kurrajong Heights (N.S.W.); R.7567, Juvenile, Illawarra (N.S.W.); R.7587 ♂, Burrawang (N.S.W.); R.8328 ♂, Mount Wilson (N.S.W.); R.8455 ♂, Moss Vale District (N.S.W.); R.9218 ♂, Williams River, Dorrigo (N.S.W.); R.10063 ♂, Blackheath (N.S.W.); R.12547 ♂, Mount Irvine (N.S.W.); R.12567

♂, Mount Wilson (N.S.W.); R.12633 ♂, R.12648 ♂, R.12652 ♂, Lowana, Dorrigo (N.S.W.); R.12788 ♂, R.12789 ♀, Mount Irvine (N.S.W.; R.17086 ♂ ,R.17087 ♀, R.17131 ♀, Dorrigo (N.S.W.); R.17097 ♂, R.17581 ♂, Point Lookout, via Ebor (N.S.W.); R.17671, Juvenile, Linden, Blue Mountains (N.S.W.); R.18555 ♀, Barrington Tops (N.S.W.); R.19178 ♂, R.19179 ♂, R.19180 ♀, Royal National Park, Sydney (N.S.W.); R.19257 ♂, 15 miles SE Moss Vale (N.S.W.); R.19430 ♂, Mount Wilson (N.S.W.); R.24493 ♂, R.24494 ♂, R.24495 ♂, R.24496 ♂, R.24497 ♂, R.24498 ♂, Falconbridge (N.S.W.).

Distribution: East of the Great Dividing Range from the Dorrigo Plateau south to Illawarra

Mixophyes schevilli Loveridge, new combination

(Pl. II, Fig. 2)

Mixophyes fasciolatus schevilli Loveridge, 1933, p. 56; Parker, 1940, p. 15.

Type locality: Millaa Millaa; Lake Barrine, 4,000 feet Bellender Ker Range, North Queensland.

Topotypic material: Millaa Millaa, 1 ♂, 2 ♀♀, collected 11-II-1963; Lake Barrine, 1 ♀ collected 11-XII-1964.

Diagnosis: Distinguished from other genera by six features listed for *M. fasciolatus* and from other species in the genus by toes strongly webbed with only two joints of fourth toe free of web, web to tip of third toe on outer edge; basal length of inner metatarsal tubercle only approximately half length of first toe; smooth skin, yellow-brown to red colour; cross bars on limbs narrow, alternating with fine dark lines, passing completely round forelimb, tibia, and foot; back of thigh with dark diffuse broad horizontal band formed from coalesing of cross bars, without pale spots; and oval tympanum, long axis tilted towards eye from vertical.

Description: Large raniform frogs (60–90 mm. snout-vent). Dorsal surface smooth, yellow-brown, tan, or darker brown with red tinge, back pattern typical *Mixophyes*—dark interorbital T or Y continuing backwards as irregular broad mid-dorsal stripe and irregular scattered blotches over remainder. Dark head stripe with continuous black upper margin, broken on lower margin between nostril and eye (Fig. 1d). Triangular patch in front of nostril edged in black, otherwise paler. Dorsal surface of limbs with distinct dark cross bars alternating with finer dark lines. Bars narrower than intervening background, continuous across ventral surface round forelimb, tibia, and foot. On thigh, bars coalese and posteriorly form a diffuse dark horizontal band, not marked by paler spots. A few scattered lateral dark spots. Ventral surface of body and thighs white, smooth except immediately adjacent to vent. Throat white, chin dusted with black. Tympanum oval, long axis tilted from vertical towards eye (Fig. 1d). Fingers not webbed, in order of length $3 > 4 > 1 > 2$. Inner metacarpal tubercle elongate to oval well developed; outer oval, barely raised from palm. Toes webbed to: just beyond sub-articular tubercle of first, tip of second and third on outer margins, proximal sub-articular tubercle and slightly beyond on inner margin of second and third respectively, and tip of fifth. At most, two joints of fourth toe free of web (Fig. 1d). Inner metatarsal tubercle shovel-shaped, without well developed edge, length approximately half length of first toe from tip of toe to junction with tubercle. Sub-articular tubercles oval, flattened. No outer metatarsal tubercle. Vomerine teeth oblique transverse plates directed from front margin of choanae to midline between choanae.

Material examined: *Queensland*: Mount Finigan (Cooktown) larvae only; Black Mountain (20 miles north of Kuranda), 2 ♂♂, 3 ♀♀; 7 miles west of Atherton, ca. 4,000 feet, 2 ♂♂, 1 ♀, 23 Juveniles; Mount Hipipamee, 1 ♂, 1 ♀; Lake Eacham, 1 ♂, 1 ♀; Lake Barrine, 1 ♀; Malanda, 1 ♂; Millaa Millaa, 1 ♂, 2 ♀♀; Tchupala Falls, Palmerston National Park, 2 ♂♂, 2 Juveniles. *Australian Museum*: R.266 ♂, 20 miles inland of Cairns (Qd.); R.770 ♂, R.4693 Juvenile, Cairns District (Qd.); R.17017 ♂, Dinner Creek, near Cairns (Qd.).

Distribution: Atherton Tablelands and coastal ranges of north Queensland from Mount Finigan (near Cooktown) south to the Johnstone River.

Key to all known species of Mixophyes

1. Toes webbed to tip of third toe on outer margin; only two joints of fourth toe free of web. Basal length of inner metatarsal tubercle half length of first toe (measured from tip of toe to its junction with metatarsal tubercle) ..... 2.
   Toes not webbed beyond distal sub-articular tubercle of third toe on outer margin; three joints of fourth toe free of web, except for a fringe along outer margin. Inner metatarsal tubercle equal in length to first toe ..... 3.

2. Dark cross bars on limbs as broad as intervening light, coalescing on posterior surface of thigh to form uniform dark background with scattered pale blotches ..... *Mixophyes iteratus.*
   Dark cross bars on limbs narrower than intervening light, coalescing on posterior surface of thigh to form diffuse dark speckled, horizontal band .... *Mixophyes schevilli.*

3. Dark cross bars on limbs sharp, well defined; widening on the margins into dark triangles, the bases of which are obvious from below ..... *Mixophyes fasciolatus.*
   Dark cross bars not sharply defined, with few irregular marginal expansions which are not visible from below ..... *Mixophyes balbus.*

Discussion

Mixophyes fasciolatus Günther as redefined here, is synonymous with *M. fasciolatus fasciolatus* Günther, defined by Loveridge (1933, p. 55) and followed by Parker (1940, p. 13) who gives a complete synonymy, in which only one reference does not now refer to this species, i.e., Fletcher (1892, p. 18) referring to specimens with fully webbed toes from the Tweed River, N.S.W. Slevin (1955) referred three specimens from Ulong, Richmond River, N.S.W., two with fully webbed toes, to *M. fasciolatus*. Moore (1961) found specimens from Lowana, Mullumbimby, and Dunoon (all in northern N.S.W.) as well as the specimens of Fletcher (1892) and Slevin (1955) were webbed to the extent considered as diagnostic of *M. fasciolatus schevilli* Loveridge. As this sub-species was erected for northern Queensland forms and *M. fasciolatus* for southern Queensland-northern N.S.W. forms, Moore (*op. cit.*) believed that, because the two forms occurred in sympatry, sub-species could not be recognised. He suggested that two species might be involved: a highland rapids species with "mountain brook" tadpoles and a coastal stream species with more extensive webbing and probably with unspecialised larvae. These "fully webbed" specimens have been transferred to the new species *M. iteratus*.

Specimens of *M. balbus* recorded in the literature under *M. fasciolatus* are listed under Australian Museum numbers for *M. balbus* and may be cross referenced to Moore's list (p. 164). Moore (*op. cit.*, p. 163) refers tadpoles, found at 5,000 feet at Point Lookout, N.S.W. to *M. fasciolatus*, but as this is the type locality for *M. balbus*, and *M. fasciolatus* is known only at lower altitudes, this reference is more likely to be to *M. balbus*.

M. fasciolatus is sympatric with *M. iteratus* and *M. balbus* in different parts of its range and exhibits no integrading with either. *M. balbus* and *M. iteratus* occur sympatricly at several localities where no intergrades have

Fig. 1. *Mixophyes fasciolatus.*

Fig. 2. *Mixophyes iteratus.*